all elements having specific gravities sufficiently greater than the mean at a given level descend through the horizontal plane at that level, and therefore displace lighter water upward through the plane at the same rate. Thus the magnitude of this upward flow of relatively warm and light water is greatest at the surface and decreases continually from the surface downward.

4. The velocity of descent of each element is proportional to the difference between its specific gravity and the average specific gravity of the water at that level.

5. The observed value of any property of the water, physical or chemical (temperature, salinity, CO, etc.), at any depth is the average of the values for all of the water particles or elements, both ascending and descending at that level.

From the assumptions stated above two fundamental equations, one a partial differential equation and the other an intrgral equation, have been deduced. The first involves the temperature of the rising elements and the second that of the rising elements, the descending elements, and the average, or observed temperature. In addition, the times, depths, and certain constants are involved. Although solution of the equations has not proved practicable, the variables entering in can be computed from temperature observations and the relation of specific gravity to temperature. Thus a series of equations, two for each depth, is formed in which the constants stand respectively for the rate of absorption of solar radiation by water, the rate of evaporation, and the rate at which solar radiation penetrates the water surface. The only observations required are the temperatures at a series of depths and their time rates of change at each depth.

Emphasis has commonly been placed upon meteorological observations rather than observations on the water itself in connection with evaporation researches. The importance of meteorological factors in evaporation is undisputed. Hence, determinations of the rate of evaporation, solely from water temperature observations without using meterological data, explicitly must imply that the external factors influence the water temperatures, and thus indirectly determine the computed value of the evaporation.

Preliminary computations have yielded values of the solar radiation, the absorption coefficient of radiation, and the rate of evaporation, all in good agreement with observation. Judging from the experience already gained, any thorough investigation of evaporation from water surfaces should involve observations of the water temperatures at different depths and times. Moreover, a sufficiently refined theoretical development along the line indicated in the present paper may contribute to the important question: What is the actual rate of evaporation of water from a lake or reservoir? (Excerpts from author's abstract.)

A detailed explanation of the above theory, together with typical numerical applications and tables for facilitating the computations, is being prepared for publication.

## WIND DRIFT IN RELATION TO GIPSY MOTH CONTROL WORK

During May and June, 1923, an interesting series of observations with small balloons was carried on by the Conservation Commission of the State of New York, Alexander Macdonald, commissioner,[1] in connection with investigations on the spread of the gipsy moth. Previous investigations had shown that wind is a very important factor in the spread of this pest. "Recently hatched caterpillars, less than a quarter of an inch long, are carried by winds when the temperature is 60° F. or higher, and under certain conditions may drift long distances, 20 or possibly 25 miles." Studies were therefore made with a view to determining the probable spread in a given period, the ultimate aim being to secure data on which to base the selection of the most practicable region for a "control zone," in which the destruction of all infestations could be accomplished with least expense and at the same time most effectively. The experiments were conducted under the immediate direction of Dr. E. P. Felt, chief entomologist.

In 1922 the most seriously infested area was that of western Massachusetts, southwestern Vermont, and northwestern Connecticut. Studies of wind frequency were therefore made at selected stations in this region and these showed during the period May 10 to June 8, 1923, that easterly winds occurred at the surface 9 per cent of the time, westerly winds 50 per cent, northerly 47, and southerly 17. The danger of spread into New York State is thus seen to be rather small, so far as surface winds are concerned. Data from the Weather Bureau stations at Albany, Burlington, and Northfield bear out this assumption.

These studies were supplemented by the use of some 7,000 hydrogen-filled toy balloons. The balloons were inflated for a minimum buoyancy, only low altitude drift being desired. Each balloon carried an addressed tag requesting the finder to fill in certain data and then forward the tag by mail. Of the nearly 7,000 balloons released reports were received from 422, about 6 per cent, and 298 of these contained detailed information. A large proportion came down in southern New England, some reaching the eastern and southern coasts and a few crossing the Sound and landing in Long Island. Thus, the general drift was southeastward. About 25 per cent maintained a practically constant direction throughout the flight; a few reached moderate heights and reversed their direction—one actually fell within 15 feet of its starting point, after being in the air more than 6 hours. *Somewhat less than 2 per cent of the total drift was in a westward direction.*

So far as the primary purpose of this investigation is concerned, the conclusion is that the spread of insects westward by wind is likely to be small and that therefore an effective control zone can be established and maintained at comparatively small cost. Meteorologically, the results are of interest as confirming in a general way our ideas of wind frequency in the lower levels, except that the percentage of easterly winds as determined from more extensive data is considerably greater than here shown. The shortness of the period of observation makes inadvisable anything like an unreserved acceptance of the results as generally representative, and, of course, to this extent the conclusion as to the effectiveness of a control zone should be likewise modified.—W. R. G.

[1] Thirteenth Annual Report, Legislative Document (1924), No. 30, pp. 158-169.

## NEW ARRANGEMENT OF METEOROLOGICAL WORK IN PORTUGAL

Under date of February 25, 1924, the Director of the Marine Meteorological Service of Portugal, writing from Lisbon, informs this office of a decree of the Portuguese Government which effects a new distribution of the meteorological activities of that country. This distribution is as follows:

Climatology: Observatorio meteorologico de Lisboa (Faculdade de Sciencias-Lisboa).

Actinometry: Observatorio meteorologico do Porto (Serra do Pilar-Porto).

Terrestrial Magnetism and Seismology: Observatorio meterologico de Coimbra (Cumeada-Coimbra).

Synoptic charts and Forecasting: Serviço meteorologico da Marinha (Lisboa).

Agricultural Meteorology: Serviço meteorologico do Ministerio da Agricultura (Lisboa).

The studies of the high atmosphere and of atmospheric electricity are for the present under the Marine Service but will probably be changed in the reorganization. The Meteorological Service of the Azores will continue in charge of the meteorological work of the islands.

It is suggested that correspondence relating to any of the several fields of work mentioned be addressed directly to the office concerned.—*C. L. M.*

## DUST STORMS OF NORTHERN IDAHO AND WESTERN MONTANA

There is a note on the origin of dust fall on page 32, volume 5, of the *Bulletin of the American Meteorological Society*, February, 1924. During my 12 years' residence in Montana and northern Idaho I have witnessed a great many dust storms. These storms, commonly known as "Palousers," have their origin in the desert region of eastern Washington and northeastern Oregon, and are of comparatively frequent occurrence. They are well known and despised by housekeepers in Kalispell, Missoula, Thompson Falls, Libby and all surrounding towns. The dust penetrates into every house and office, making it possible for anyone to write his name on the furniture. When accompanied by rain or snow, the window panes and buildings are besmirched with streaks of red dirt. To have one of these storms happen immediately after painting a house is exasperating. The dust travels over the undulating Palouse region in northern Idaho where the deposits have laid the foundations for one of the richest wheat-producing counties in America. Petersen (see *Science*, January 27, 1923) proved by repeated measurements that this deposit amounted to 2 inches per century. The dust is laid down in the mountains of northern Idaho where it may be seen any day and anywhere during the summer months. Here it no doubt has profoundly influenced the growth and distribution of one of America's most valuable timber trees, the western white pine, for the best growth and development of this species takes place on the deep soils which lie directly in the path of the westerly winds carrying and depositing this dust. One very pronounced dust storm, which many will remember, occurred in March, 1917, when the desert region was dry and bare, but the forested area under cover of snow. At this time a sample of the dust as it had fallen on the snow in northern Idaho was taken, the snow melted, and the amount of dry soil weighed. This showed that the deposit in one single storm amounted to 600 pounds per acre. The dust was observed sticking to the limbs and leaves of trees generally in the Priest River Valley throughout the following summer.

Evidently these storms should be of more than passing interest in that they influence outdoor occupations, farm crops, and timber production.—*J. A. Larsen.*

## SOUTH PACIFIC WEATHER REPORTS AND STORM WARNINGS

[Reprinted from Apia (Samoa), *Radio Bulletin*, *Samoa Times*, January 18, 1924]

South Pacific radio stations are cooperating withthe Apia Observatory in collecting weather reports and broadcasting storm warnings. Suva, Nukualofa, Norfolk Island, Vila, Awanui, and Noumea sent their reports to Apia. Vila exchanges weather reports with Noumea. Norfolk Island passes its report to Suva. Noumea sends its report from Noumea and Vila to Suva. Suva transmits its own and the reports from Vila, Noumea, and Norfolk Island to Apia. Papeete and Nukualofa report direct to Apia.

The message consists of:

1. The station from which the report emanates
2. The barometer.
3. Thermometer—dry.
4. Thermometer—wet.
5. Wind—direction.
6. Wind force by Beaufort scale.
7. Sky and weather in Beaufort letters.

The station broadcasting weather reports makes each report successively. The break sign, dash-dot-dot-dot-dash (bk) separates each report, e. g.—

Apia—30.16–80.78. ENE. 3 BC (bk).

Suva—30.08–79–78 ENE. 5 OCR (bk) and so on, finishing with the time that observations were made, 0330 or 2030 M. M. T. civil (9 a. m. or 4 p. m. Apia time).

These reports are collected by Apia, turned over to Apia Observatory, and broadcasted with storm warnings and Apia's weather report at 2330 G. M. T. civil (noon Apia time) and at 0830 G. M. T. civil (9 p. m. Apia time). When storm warnings are issued Apia broadcasts on 2,000 meters and Suva repeats on 600 meters. If Apia issues a storm warning, Awanui broadcasts the warning immediately after the routine New Zealand weather report and informs the Meteorological Office, Wellington.